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A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

This document is one in a series intended to furnish such technological information. Divided into four sections, the Compilation presents a number of devices and techniques that may be of interest to production engineers and shop workers in both small and large organizations. The sections include articles on cutting, shaping, and forming; working with metals; and coatings.

Additional technical information on the articles in this Compilation can be requested by circling the appropriate number on the Reader Service Card included in this Compilation.

The latest patent information available at the final preparation of this Compilation is presented on the page following the last article in the text. For those innovations on which NASA has decided not to apply for a patent, a Patent Statement is not included. Potential users of items described herein should consult the cognizant organization for updated patent information at that time.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this Compilation.

Jeffrey T. Hamilton, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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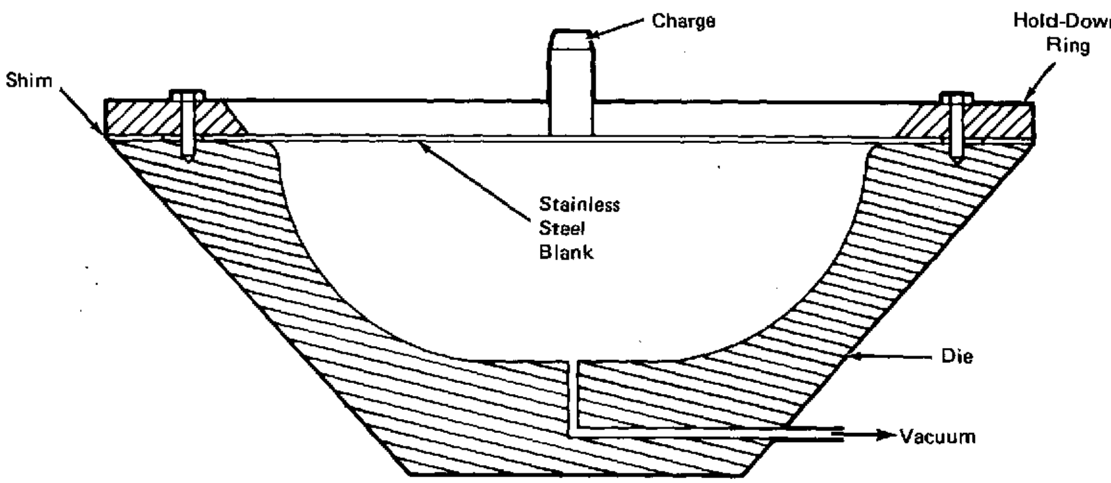
Contents

Section 1. Cutting, Shaping, and Forming

ONE-STEP EXPLOSIVE FORMING OF METAL: A PROCESS IMPROVEMENT



O_2 Tank-Dome Fabrication Setup

Explosive forming is a process that uses the force of an explosive charge to shape a blank metal stock that has been placed in a die (see figure). It has been quite difficult to control the dimensions of the formed parts. For instance, domes formed by this method exhibit thinning and distortion.

This poor dimensional control is attributed to an uneven local frictional force between the blank stock and the die. Two factors are important contributors to this disparity: (1) The flatness tolerances applied to the fabrication of the hold-down rings are not stringent enough; and (2) the explosive charge is placed in the visually determined center of the blank, which in fact may not be the true center.

In an improved version of the process, the hold-down ring is machined to a uniformly flat surface. Then, a jig is used to position the explosive accurately. In addition, shims are installed to prevent the ring from cocking and to improve the uniformity of the clamping surface (see figure).

When used to form domes, these improvements eliminate thinning and distortion. As a result, the number of rejects in the process is markedly reduced.

Source: J. F. Schuessler and
R. L. Rhoton of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-22585)

Circle 1 on Reader Service Card.

GRINDING-WHEEL DRESSER

A relatively inexpensive grinding-wheel dresser can maintain a very precise radius on the grinding wheel. In precision work, the radius of the wheel must be dressed after each cut, without changing the wheel-to-lap distance along either the X or Y axis.

Commercially available wheel dressers require considerable set-up time after each cut. They will not swing out of the way to allow a cut to be made unless the dresser is removed from the lathe.

This wheel dresser can form variously sized radii on the grinding wheel. It is rigidly clamped to the cross slide of the lathe. The grinding head is attached to the compound slide of the lathe, allowing the wheel to be fed into the dresser by turning the handle on the compound shield (Figure 1). In this way, the cutting edge of the wheel is in exactly the same position on the

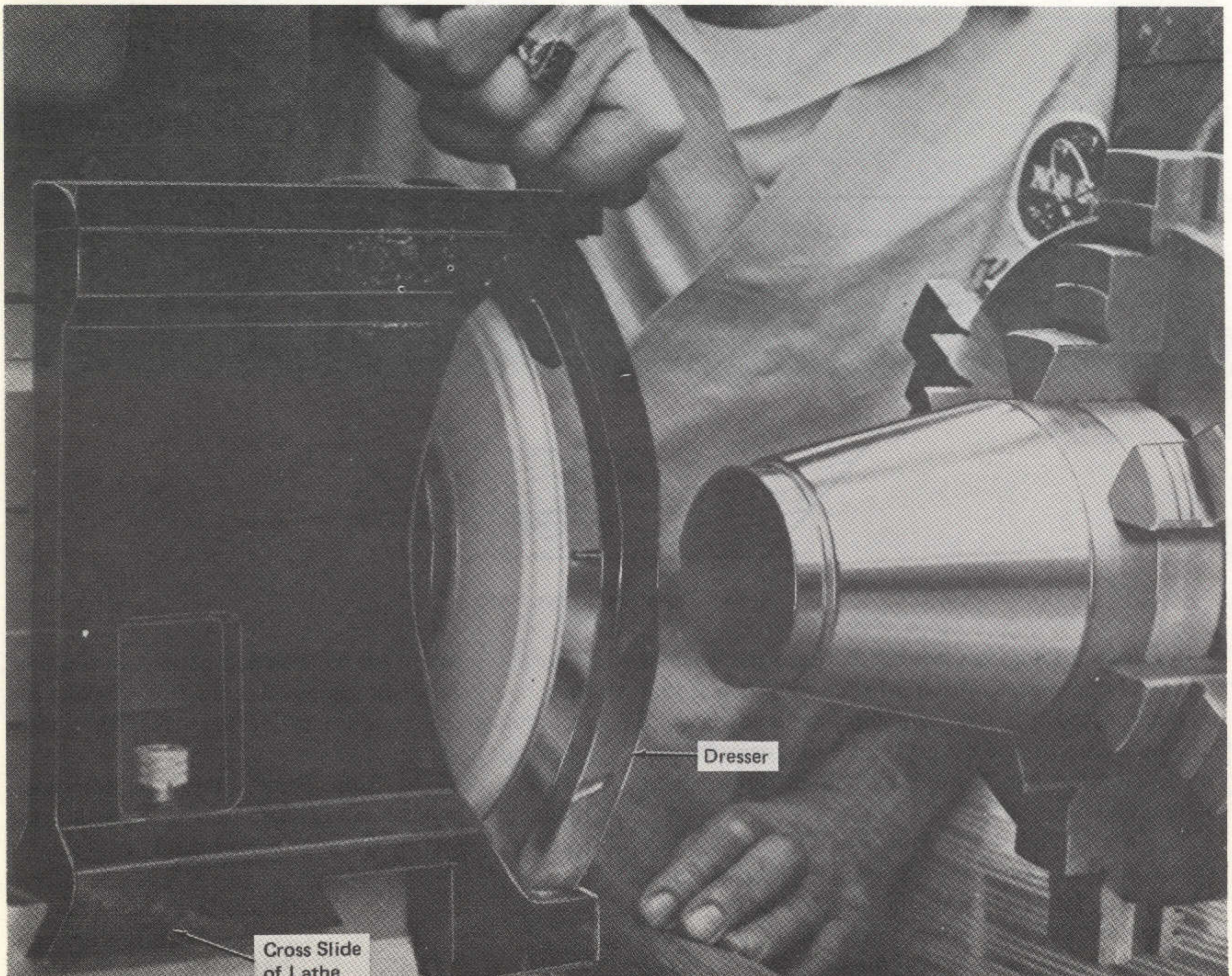


Figure 1. Aligning Wheel With Dresser

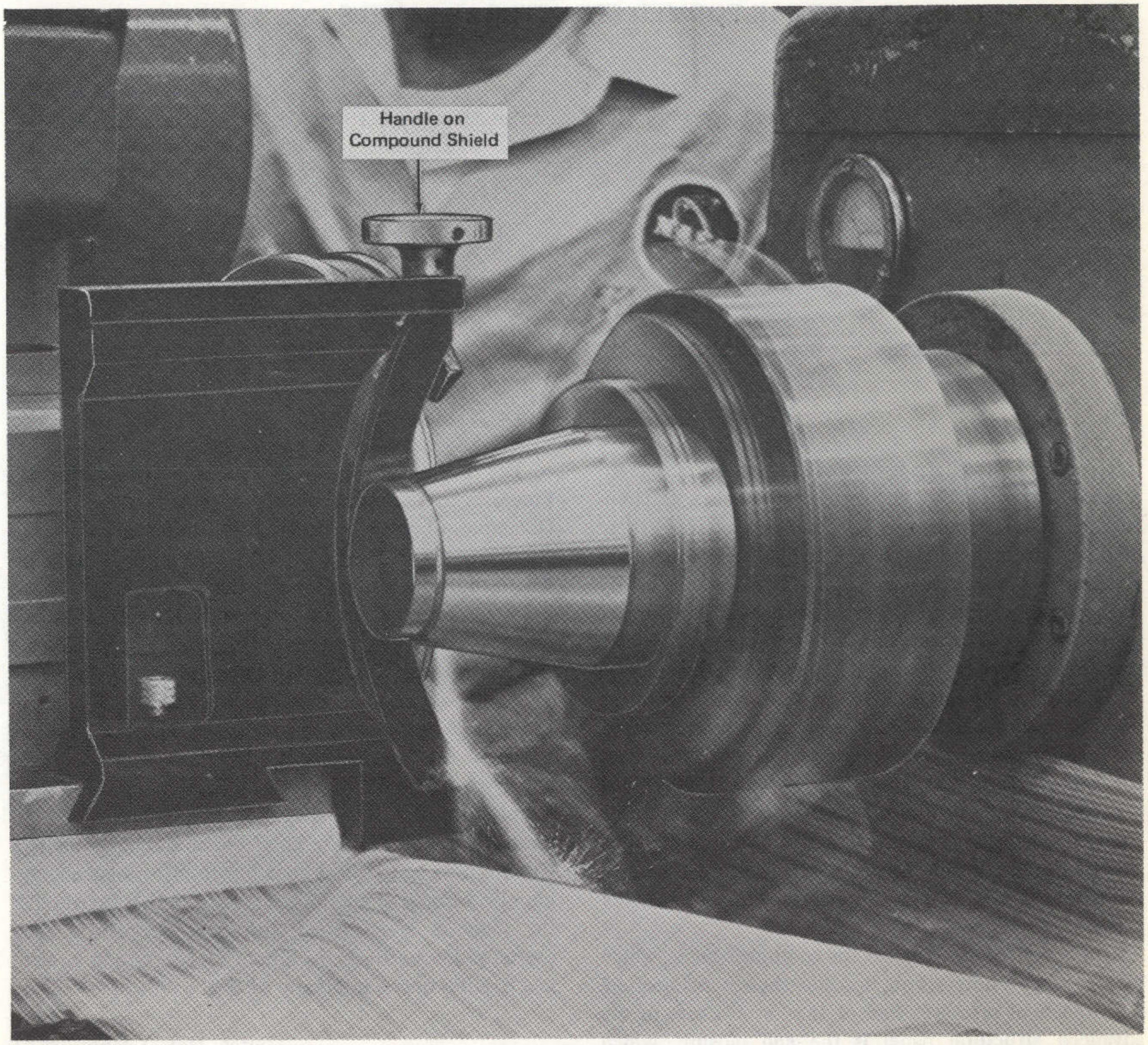


Figure 2. Dresser Swings Out of the Way

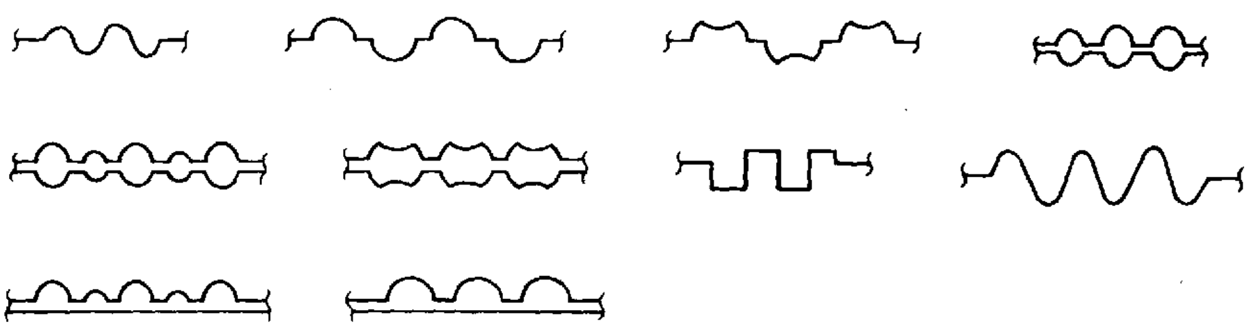
X and Y axes after dressing. No compensation is required for the material removed from the grinding wheel during the dressing. Afterwards, the dresser will swing behind the cutting edge of the wheel, where it will not interfere with the cut (Figure 2).

This dresser is now being used during the fabrication of aspheric laps for grazing-incidence optics. It could be used with any lathe having a tool-post grinding attachment, and would be very helpful in small shops that do not have expensive grinding equipment.

Source: Edgar Kauffman, Robert Hessler, and Dott Wells
Goddard Space Flight Center
(GSC-11140)

No further documentation is available.

BREAK-FORMED STRUCTURAL PANELS



Cross Sections for Break-Formed Panels

Several methods are used to form structural panels. Stretch-formed panels and corrugated panels with circular-arc cross sections are common. However, these methods do not offer the versatility or proper end closings for complex structures. The use of break-forming fabrication techniques produces a structure of lighter weight and offers improved economy, reliability, and versatility when compared to current methods.

This technique should be of particular interest to the building trades and to railroad-car construction firms. Indeed, corrugated panels have been used in these areas for many years, but they had not been developed sufficiently to be of use in aerospace construction. The aerospace industry has profited from this commercial experience and is able to return, to the private sector, the dividend of a new, more economical, and versatile process.

These panels are designed for combined loads, which include edge compression, inplane shear, and bending due to lateral pressure. One of the key features of the advanced structural panel is the end closure, which forms the transition from the uniform-beaded or tubular section to the flat required for attachment at the end of the panel. The panel must be formed from thin sheet without compromising either the efficiency available in the uniform section or the integrity of the end enclosure.

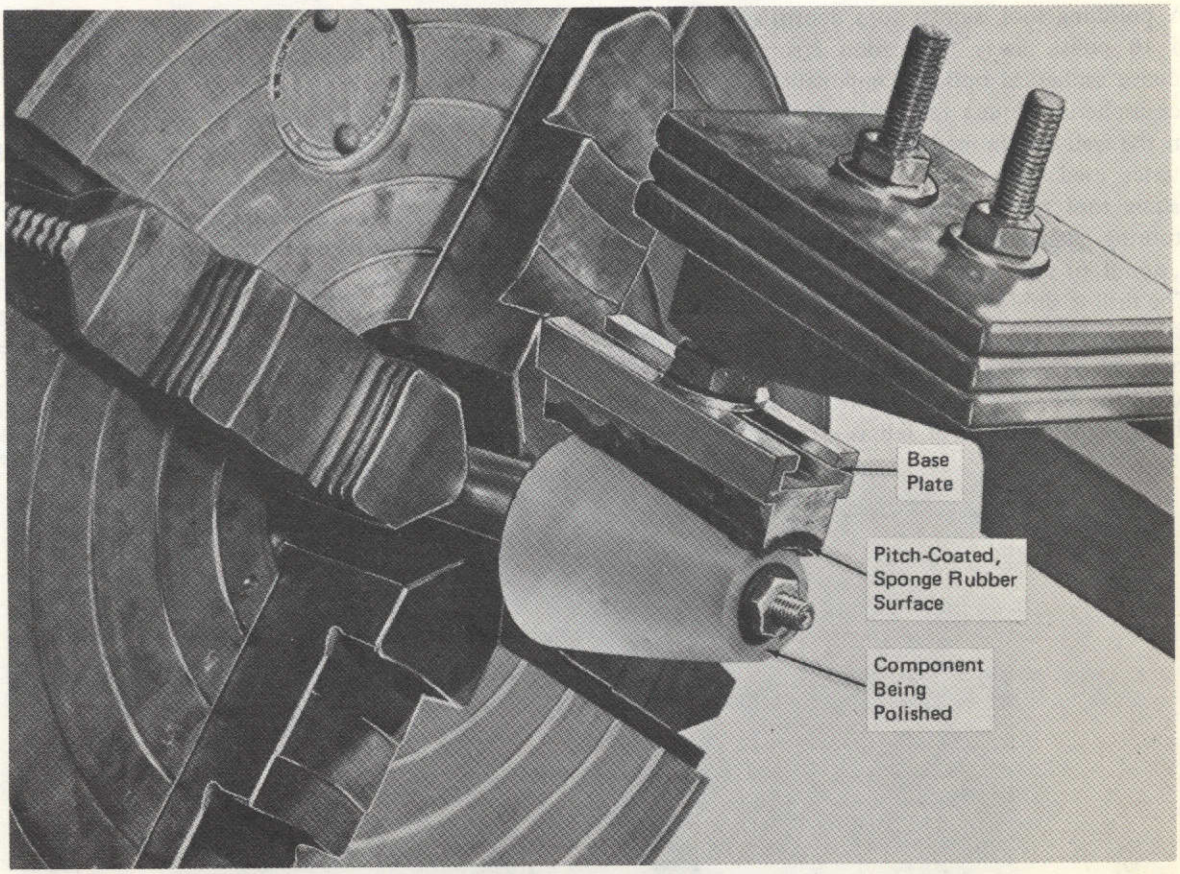
The panels are made by three separate forming processes to produce panels of the lightest weight. (Examples of a few possible cross sections are shown in the figure.) The sheet material is first formed into full-length uniform corrugations of the desired cross section by break-forming. Break-forming bends but does not stretch or thin the material. This approach is versatile and controls the cross section geometry.

In the second step, matched dies are used to reform the ends of the panels, increasing the width of the flats between the end closures. The last step is high-energy-rate forming, such as electrohydraulic forming, to produce the final shape of the end closures. In electrohydraulic forming, an electrical discharge melts a wire inside a water-filled chamber to effect high energy-impulse formation of the part using only a female die; the material is stretched and bent very little. The overall process affords maximum versatility and control and requires only a minimum of final handwork.

Source: Max D. Musgrove of
The Boeing Company
under contract to
Langley Research Center
(LAR-11171)

Circle 2 on Reader Service Card.

CONTOUR POLISHING GLANCING-INCIDENCE OPTICS



Polisher for Glancing-Incidence Optics

Using the contour polisher shown in the figure, glancing-incidence optical aspherics may be contoured to within $\lambda/10$ rms. The process is simple and rapid.

The polisher is placed on top of the aspherical optical element. The element rotates about its axis at 40 rpm. At the same time, the polisher oscillates perpendicular to the rotation. The ratio of the oscillation to the length of the blank is 1:6.4, and the rate of oscillation is 150 cycles/minute. A weight of 0.35 lb per in.^{2} (25g per cm^2) of pitch surface is applied to the polisher.

The base of the polisher is a rectangular metal plate, the same length as the optical component. The width of the plate is between one fourth and one third the median diameter of the component. One surface of the base is curved to match the aspheric. On this surface, 0.12 in. (3 mm) of sponge rubber are bonded with red sealing wax. The rubber is shellacked and dried; then 0.08 in. (2 mm) of pitch are applied. The shellac provides improved adherance.

The pitch used here should be more viscous than that normally used for polishing. In conventional polishing, 60 to 80 percent of the area being polished is in contact with the polisher. Here only 10 percent is. The result is increased slurry evaporation and the associated heat loss. A 1:3 ratio, by weight, of 180° and 194° F (82° and 90° C) melting-point coal tars has proven effective for this technique.

The aspherics is contoured by shaving away small amounts of pitch that correspond to "low" zones. The method has produced surfaces of better than $\lambda/10$ rms (λ:5460A) that are free of scratches and "sleets".

Source: Charles Fleetwood, Jr.
Goddard Space Flight Center
(GSC-11781)

No further documentation is available.

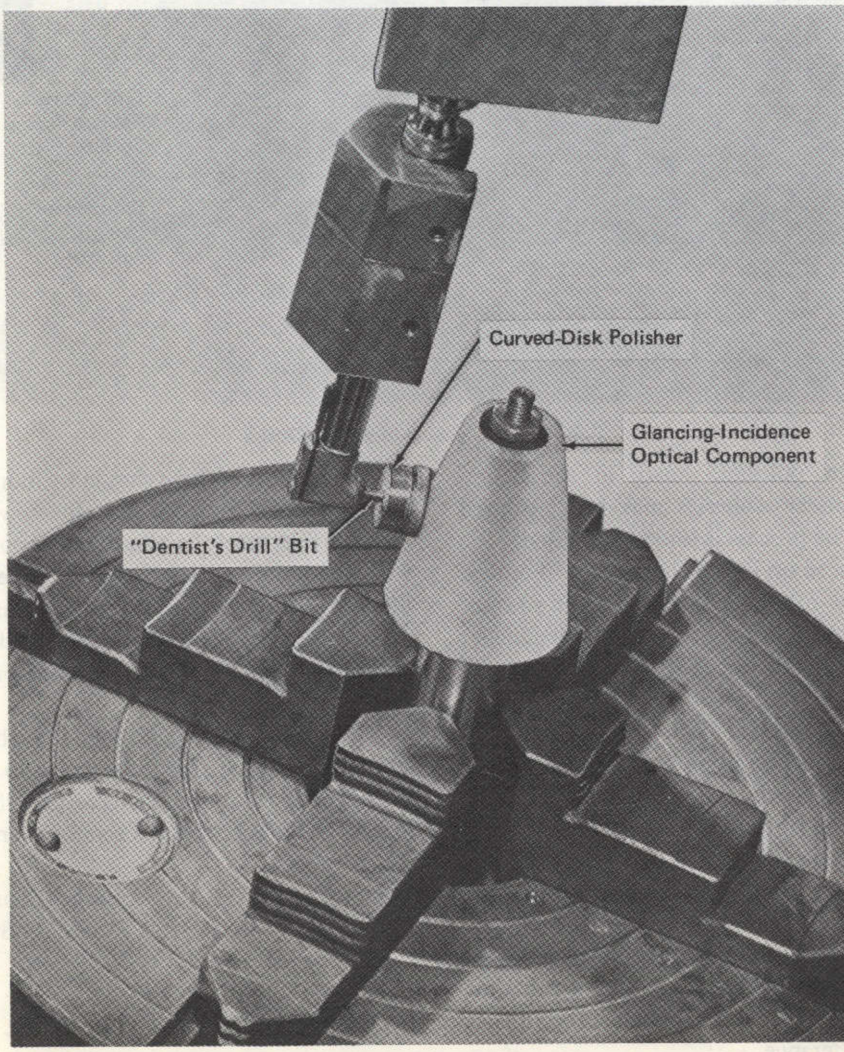
ZONAL CONTOURING USING A "DENTIST'S-DRILL" POLISHER

A polishing tool, similar to a dentist's drill, can be used to polish away fabrication errors on glancing-incidence aspherical optical components. Glancing-incidence aspherics require fabrication techniques differing from the well-known methods for the normal-incidence aspherics used with most of today's telescopes. This polishing tool reduces the cost and time in optically contouring glancing-incidence optical components of ring, donut, or solid shapes.

The drill is similar to that used by a dentist. But the drill bit is replaced with a 13-mm (0.5-in.) diameter curved-disk (see figure). The curvature of the disk is matched to the median curvature of the aspheric. A pitch-impregnated piece of felt is attached to the disk with red sealing wax. Most types of wool felt can be used, and any optical-grade pitch of medium hardness is satisfactory.

The pitch-impregnated felt polisher will withstand greater pressures than a polisher using only pitch. It will last longer, and the greater pressure saves time by increasing the rate of material removal.

When shaping it, the optical component is rotated at around 48 rpm. The disk polisher rotates at nearly 1300 rpm. A weight of from 281 to 1,400 g/cm^2 (4 to 20 psi) is applied. The felt is centered over the error zone, and a slight traverse motion is applied. Any suitable polishing agent such as water and cerium oxide may be used.



Zonal Contouring Technique

This polisher has been used to finish the optics for glancing-incidence extreme-ultraviolet telescopes at the Goddard Space Flight Center. It should also be useful with other glancing-incidence optical systems, and possibly with X-ray telescopes and normal-incidence optics.

Source: Charles Fleetwood, Jr. and
Charles Davis
Goddard Space Flight Center
(GSC-11780)

No further documentation is available.

STEPOVER CHART FOR RAMPING CUTS

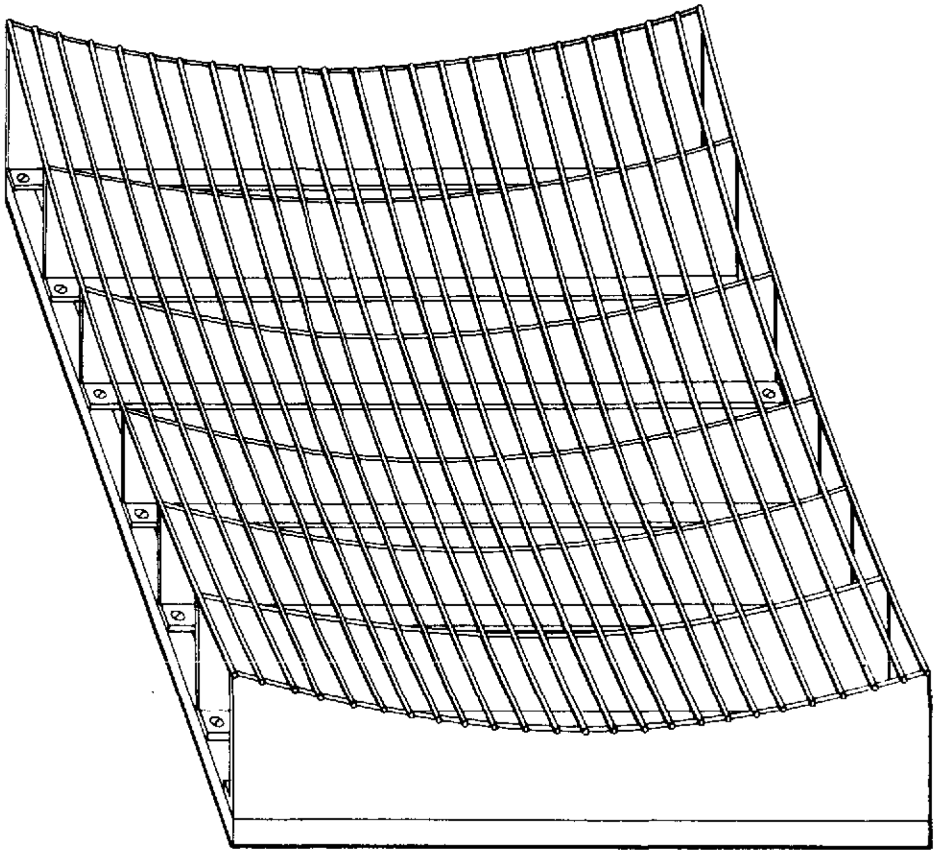
DIAMETER	FILLET RADIUS	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
.250	0	.172	.126	.103	.089	.079	.071	.065	.059	.054	.050	.046	.041	.037	.033	.028	.023	.016
	.060	.121	.095	.081	.073	.067	.062	.058	.054	.050	.047	.044	.040	.036	.033	.028	.022	.016
	.090	.024	.076	.068	.064	.060	.057	.054	.051	.048	.045	.043	039	036	.032	.028	.022	.016
.375	0	.216	.156	.128	.110	.097	.086	.080	.073	.067	.061	.056	.051	.046	.040	.035	.028	.020
	.060	.178	.132	.110	.097	.088	.080	.074	.069	.064	.059	.054	.049	.045	.040	.034	.027	.020
	.090	.156	.119	.101	.090	083	.076	.071	.066	.062	.057	.054	.049	.045	.040	.034	.027	.020
	.120	.129	.104	.090	.083	.077	.072	.068	.064	.060	.056	.053	.048	.044	.040	.034	.027	.020
.500	0	.253	.181	.148	.127	.113	.101	.092	.084	.077	.070	.065	.059	.053	.047	.040	.033	.023
	.060	.220	.162	.133	.117	.104	.095	.087	.080	.074	.069	.063	.057	.052	.046	.040	.032	.023
	.090	.203	.151	.125	.111	.100	.092	.085	.079	.073	.067	.063	.057	.052	.046	.040	.032	.023
	.120	.184	.139	.117	.105	.096	.088	.082	.077	.072	.066	.062	.056	.052	.046	.040	.031	.023
.750	0	.313	.223	.182	.156	.138	.124	.113	.103	.095	.087	.079	.072	.065	.057	.049	.040	.028
	.060	.288	.205	.169	.148	.132	.119	.109	.100	.092	.085	.078	.071	.064	.057	.049	.039	.028
	.090	.275	.199	.163	.143	.128	.117	.107	.099	.091	.084	.076	.070	.064	.057	.049	.039	.028
	.120	.261	.191	.157	.139	.125	.114	.105	.097	.090	.083	.076	.070	.064	.057	.049	.039	.028
1.000	0	.363	.259	.210	.181	.160	.144	.131	.120	.109	.100	.092	.083	.075	.066	.057	.046	.032
	.060	.343	.245	.199	.173	.154	.139	.127	.117	.107	.098	.091	.082	.074	.066	.056	.045	.032
	.090	.332	.238	.194	.169	.151	.137	.125	.115	.106	.098	.090	.081	.074	.066	.056	.045	.032
	.120	.320	.231	.189	.166	.148	.135	.124	.114	.105	.097	.089	.081	.074	.066	.056	.045	.032
	.180	.296	.216	.178	.158	.142	.130	.120	.111	.103	.096	.088	.080	.073	.066	.056	.045	.032
	.250	.264	.197	.165	.148	.135	.124	.116	.108	.101	.094	.087	.080	.073	.065	.056	.045	.032
1.250	0	.408	.289	.235	.202	.179	.161	.146	.134	.122	.112	.102	.093	.084	.074	.063	.051	.036
	.060	.389	.278	.225	.196	.174	.157	.143	.131	.121	.110	.101	.092	.083	.074	.063	.050	.036
	.090	.380	.272	.220	.192	.171	.155	.142	.130	.120	110	.101	.091	.083	.074	.063	.050	.036
	.120	.370	.265	.216	.189	.169	.153	.140	.129	.119	.109	.100	.091	.083	.073	.063	.505	.036
	.180	.349	.252	.207	.182	.163	.149	.137	.126	.117	.108	.100	.091	.082	.073	.063	.050	.036
	.250	.323	.236	.195	.173	.157	.144	.133	.124	.115	.106	.099	.091	.082	.073	.063	.050	.036
1.500	0	.448	.318	.258	.222	.196	.176	.160	.146	.134	.123	.112	.102	.092	.081	.069	.056	.040
	.060	.431	.307	.248	.216	.191	.173	.157	.144	.132	.121	.111	.100	.091	.081	.069	.055	.039
	.090	.422	.301	.244	.213	.189	.171	.156	.143	.132	.121	.111	.100	.091	.081	.069	.055	.039
	.120	.414	.296	.240	.210	.187	.169	.155	.142	.131	.120	.110	.100	.091	.081	.069	.055	.039
	.180	.395	.284	.232	.203	.182	.165	.152	.140	.129	.119	.110	.099	.091	.081	.069	.055	.039
	.250	.372	.270	.222	.196	.176	.161	.148	.137	.127	.117	.109	.099	.090	.080	.069	.055	.039
2.000	0	.519	.367	.298	.256	.226	.204	.185	.169	.155	.142	.130	.118	.106	.093	.080	.065	.046
	.060	.505	.358	.289	.251	.223	.201	.183	.167	.153	.140	.129	.116	.105	.093	.080	.063	.046
	.090	.497	.353	.286	.249	.221	.199	.181	.166	.153	.140	.129	.116	.105	.093	.080	.063	.046
	.120	.489	.348	.282	.246	.218	.197	.180	.165	.152	.139	.128	.116	.105	.093	.080	.063	.046
	.180	.474	.339	.275	.240	.214	.194	.178	.163	.150	.138	.127	.115	.105	.093	.080	.063	.046
	.250	.455	.327	.267	.234	.209	.190	.175	.161	.149	.137	.126	.115	.105	.093	.080	.063	.046

When tapered sections are required, the flow of operations has to be suspended while the machinist calculates the ramping cut needed and programs the cutting tools accordingly. To save time in these operations, a chart was devised to provide a ready reference of stepover values for scallop heights. The diameter of the cutter and its fillet radius are taken into account; and the machinist is able to read off the adjustment necessary, for cutting up or down on any angle, without resorting to calculations. This enables the cutter to be set without delay.

Source: W. R. Vaughn of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17288)

No further documentation is available.

FABRICATION OF IRREGULAR SURFACE SHAPES



General Mechanical-Design Approach to the Construction of an Ellipsoidal Reflector. Surface of Ellipse is Developed From Closely-Spaced Parallel Rods Which Are Positioned by Threading Through Holes Accurately Located in Flat Sheets Which Are, in Turn, Attached to a Rigid Flat Reference Plane.

A new technique has been developed for forming structures with precise but irregular shapes. The technique is relatively inexpensive and adaptable to mass production. It was conceived originally for the fabrication of elliptical microwave reflectors, but may be useful in constructing bridges and buildings and as a reinforcement method for curved concrete structures.

The general technique is illustrated in the figure. A large number of holes are drilled or punched in flat plates that are then mounted on a flat supporting frame. The positions of the holes are chosen according to the final shape desired. For mass production, the process can be computerized.

Thin round rods are threaded through the holes to form the desired surface. After the rods are in place, the excess portion of the flat plates may be cut away. The accuracy of the construction is assured through the positioning of the holes, and further precision fixture or measuring systems are not required.

Source: W. C. Brown of
Raytheon Company
under contract to
Marshall Space Flight Center
(MFS-22205)

Circle 3 on Reader Service Card.

Section 2. Metal Fabrication Techniques

METALLIC MASKING FOR ELECTROPLATING

Metallic masking can eliminate unwanted chemical attack on the basis metal during electroplating. Experience at the Goddard Space Flight Center's Engineering Services Division has shown that a copper mask prevents aluminum from being accidentally attacked by a gold plating solution during selective electroplating.

Conventional maskants such as lacquer or electroplater's tape frequently break down. Lacquer coats may be somewhat porous, allowing the plating solution to penetrate to the metal. Electroplater's tape frequently lifts at the edges during processing.

These problems are solved when a metallic mask is used in conjunction with the tape or lacquer. For example, a copper mask can be used when selectively gold plating aluminum. The piece is prepared for plating, and a copper mask is electroplated over the entire surface. Then, the area not to be gold plated is further masked with tape or lacquer. Should this outer mask break down, the copper will act as a second line of defense and protect the aluminum from attack by the gold-plating solution.

After the piece is electroplated and the lacquer or tape is taken off, the exposed copper can be removed chemically with nitric acid. This will not harm the gold or the aluminum.

This method has been used successfully to electroplate a gold band 0.051 cm (0.02 in.) thick and 1.270 cm (0.5 in.) wide, to be used as a radiation shield on the inside of an aluminum reticle holder.

Source: Earl D. Ellis
Goddard Space Flight Center
(GSC-11203)

No further documentation is available.

PROTECTION FROM HYDROGEN-ENVIRONMENT EMBRITTLEMENT

Alloys, such as Inconel, having high strength-to-weight ratios become embrittled in a hydrogen environment. This embrittlement may be avoided by applying a braze-wash coating of a hydrogen-impermeable material such as copper. However, at the high temperatures used for brazing, the coating tends to liquify and run off, leaving the part unevenly protected.

Excessive run-off may be prevented by covering the part with a fine-mesh stainless steel wire screen. The screen is cut and contoured to fit the part. It is then attached by resistance spot welding. After spot welding, a braze-alloy powder and a flux are "painted" on the screen, and the assembly is brazed at an appropriate temperature. The wire screen holds the braze by capillary retention, insuring uniform coverage of the part.

Source: D. I. MacFarlane of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-19172)

Circle 4 on Reader Service Card.

SPECIALLY-TREATED STAINLESS-STEEL SCREWS FOR HIGH-TEMPERATURE USE IN A VACUUM

After lengthy exposure in a vacuum at temperatures as high as 810 K (1000° F), stainless-steel screws are difficult to remove. Screws used in holes tapped in stainless steel, or with stainless-steel nuts, will gall, seize, and sometimes weld together. This is especially true for screws with machine-cut threads. The spalling, or crazing, of the threaded surfaces (see Figure 1) contributes to the seizing. The jagged surface edges tend to interlock with similar surfaces on nuts or tapped holes.

Seizing can be avoided by using oxidized stainless-steel screws, with rolled threads, coated with boron nitride powder. The boron nitride lubricant does not outgas as do conventional lubricants such as molybdenum disulfide. The smooth surface of the rolled threads (see Figure 2) helps to preclude binding and interlocking of the threaded surfaces.

The screws and nuts are prepared as follows:

1. Degrease the parts.

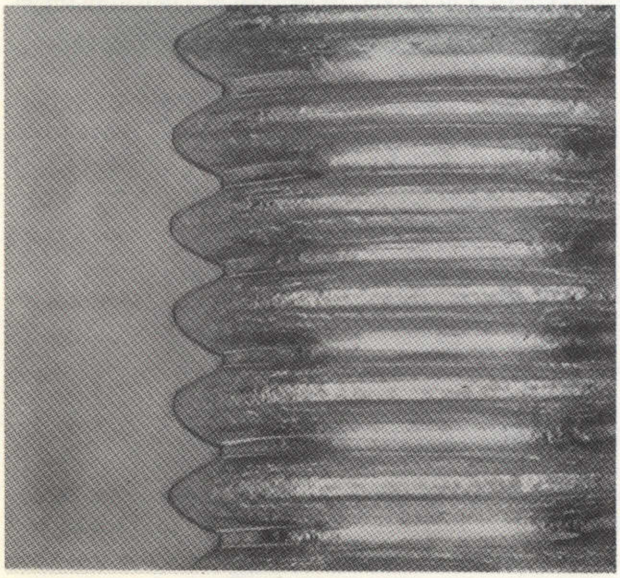


Figure 1. Spalled Thread

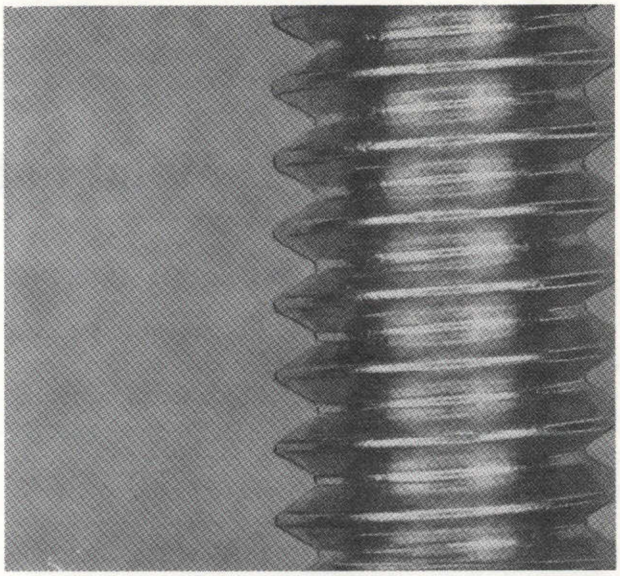


Figure 2. Rolled Thread

2. Passivate the parts with a 20% (by volume) solution of nitric acid, containing sodium dichromate (4 ounces per gallon of solution). Allow 45 minutes for passivation; then rinse three times with tap water: cold, hot, and a final cold rinse. Air-dry the parts.
3. Heat the parts in a furnace (atmospheric) at 1150 K (1600° F) for one hour. Remove the parts from the furnace and air-cool them.
4. Clean the parts ultrasonically.
5. Apply the boron nitride powder to the threads upon assembly.

This technique should be of interest throughout the vacuum industry, particularly to research engineers working with and developing hardware that is exposed to a high-temperature vacuum environment.

Source: Lawrence A. Mueller,
Ernest A. Koutnik, and
Vincent R. Lalli
Lewis Research Center
(LEW-11176)

No further documentation is available.

METHOD OF RAPIDLY AGING AN ELECTROLYTE

The electrodeposition of nickel has required costly, time-consuming preliminary operations. Furthermore, the nickel plating frequently suffers from spotty adhesion and marginal tensile properties. Two rapid methods of aging nickel sulfamate electrolyte solution overcome these difficulties. Electrodeposition with the aged solution results in a heavy nickel coating with consistent optimum mechanical properties. In addition, the process does not require the use of additives.

The two methods that may be used to speed the aging process are:

1. The anode current may be increased. A sevenfold increase in current reduces the required time by a factor of 3.5 (from 700 to 200 ampere-hours per gallon of electrolyte).
2. Aged nickel anode chips can be used with new electrolytes, or conversely, an aged electrolyte can be used with new anode chips. When used with the high current density, this technique can further reduce the required time by from 65 to 75 percent.

Source: J. E. O'Tousa and
F. T. Schuler of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-19178)

Circle 5 on Reader Service Card.

TECHNIQUE FOR VISUAL INSPECTION OF NICKEL-PLATING QUALITY

During the fabrication of platelet-based components (e.g., injectors or chambers) several thin nickel platelets are bonded by braze-alloy deposition. It is difficult to determine whether the nickel sheet has been nickel plated over the entire surface, since the nickel base and the nickel plate are similar in appearance.

The plating may be examined visually if the nickel base metal is colored. A thin flashing of electrolytic copper, 2 to 8 micrometers thick, colors the base metal and allows areas of incomplete plating to be seen with the eye.

Bonds formed with this technique were subjected to metallographic analysis and found to be excellent. Furthermore, the method simplifies cleaning and handling, thus reducing quality-control costs and increasing reliability.

Source: J. Addoms, R. Boyce, and
K. Gustafson of
Aerojet Liquid Rocket Co.
under contract to
Marshall Space Flight Center
(MFS-21151)

No further documentation is available.

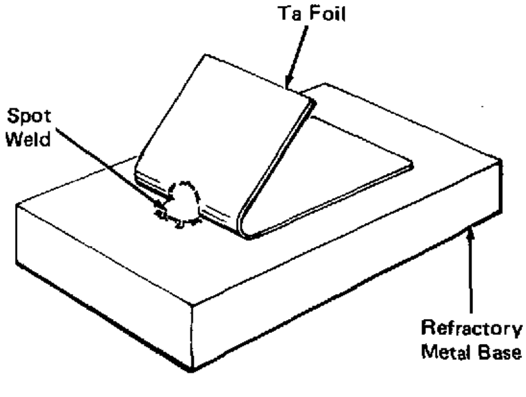
NEW PROCESS FOR WELDING BARE-JUNCTION THERMOCOUPLES TO REFRACTORY METALS

A bare chromel/alumel thermocouple welded directly to niobium 1% zirconium is unreliable due to crystallization and embrittlement of the juncture, caused by the high current load required to make the weld. In a new process, a bare-junction thermocouple is joined to a refractory metal with a weld of sufficient strength to have a long effective life at high temperatures [1700° to 2400° F (1200 to 1600 K)].

The new process makes use of an interface material [0.005-in. (0.0127-cm) Ta foil] that is welded easily to refractory metal and the thermocouple wire. The thermocouple wire can be welded to the tantalum with an 80% to 90% lower power factor. This low-power spot weld eliminates the junction degradation that occurs when welding without the interface material. The steps in this new process are as follows:

Step 1. The surface of the refractory metal is cleaned with a clean smooth file. Clean degreased tantalum foil 0.005-in. (0.0127-cm) thick (minimum) is spot welded to the refractory metal at about 100 to 200 watt-seconds of power in one spot of approximately 1/16-in. (0.015-cm) diameter.

Step 2. The foil is peeled back until the area spot-welded shears away from the parent foil. This leaves a raised area of Ta approximately 1/16 in. in diameter and 0.005 in. high on the refractory metal surface (see Figure 1).



Step 1. Steps One and Two

Step 3. The 0.024-in. (0.61-cm) diameter alumel wire of the thermocouple is laid across the Ta interface material and spot-welded at 25 to 35 watt-seconds of power (see Figure 2).

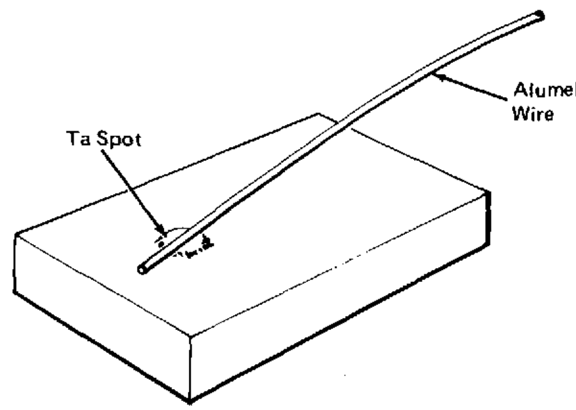


Figure 2. Step Three

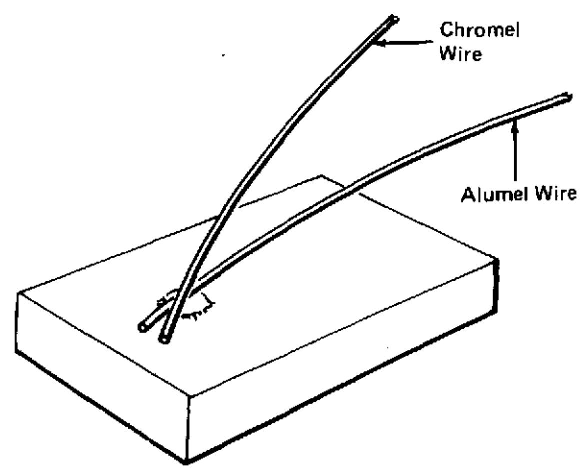


Figure 3. Step Four

Step 4. The chromel wire is laid across the alumel wire, over the weld at a 15° to 30° angle, and is spot-welded to the alumel wire to complete the thermocouple junction. From 20 to 28 watt-seconds are used to make a secure junction (see Figure 3).

Note: For best results, all welds should be made with an argon cover gas and with a tungsten electrode. The positive terminal is connected to the refractory metal base, and the negative terminal is connected to the tungsten electrode.

Source: Glenn M. Haskins of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11435)

No further documentation is available.

ELECTRODEPOSITED COPPER FOR HIGH-TEMPERATURE USE

The ductility of electrodeposited copper at temperatures above 533 K (500° F) is considerably less than that of wrought copper. For this reason, electrodeposited copper has been restricted to comparatively low-temperature uses.

In a new process employing modified parameters, electrodeposited copper is produced with an elongation of 20% at 644 K (700° F), as compared with 5% for the standard process.

The basic electrolyte in the new process consists of reagent-grade copper sulfate ($CuSO_2{-}5H_2O$) at a concentration of 21 to 24 g/1 (28 to 32 oz/gal) and reagent-grade sulfuric acid at 6 to 7.5 g/1 (8 to 10 oz/gal). In addition, the electrolyte contains 0.39 g/1 (1.5 g/gal) of pentose. The anodes are chips of low-oxygen-content copper held in titanium baskets, with polypropylene bags as covers. A controlled current density of 215 A/m^2 (20 A/ft^2) is used, as compared to current densities of from 107 to 645 A/m^2 (10 to 60 A/ft^2) for conventional processes. The electrolyte bath is continuously agitated and is kept at 303 to 306 K (85° to 90° F), which is slightly lower than for conventional processes.

In addition to its increased ductility, copper electrodeposited by this process possesses a much finer grain structure. It can, therefore, be used where high temperatures and structural loading previously excluded the use of electrodeposited copper.

Source: F. T. Schuler and
H. A. Tripp of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-19173)

Circle 6 on Reader Service Card.

ELECTRON-BEAM WELDING OF DISSIMILAR METALS

Electron-beam welding is one popular method of joining dissimilar metals. It minimizes distortion and reduces the size of the heat-affected zone. However, in some cases, the electron beam tends to wander away from its target position on the weld.

This unwanted motion of the beam has been attributed to the difference in permeability of the materials being welded. The electron beam, consisting of moving electrons, induces a current in the metals and causes each to create a magnetic field. The beam is then deflected by the strong field of the high-permeability material toward the weaker field of the low-permeability material. The deflection of the electron beam can be eliminated by making it subject only to a uniform magnetic field. This can be done by plating the low-permeability material with a thin coat of the high-permeability material.

In initial attempts to butt weld nickel (high permeability) to copper (low permeability), the electron beam was deflected about 8° within the weld toward the copper side. This deflection was eliminated by plating a thin layer of nickel, about 0.051 cm (0.020 in.), over the entire copper piece. Then the joining surface was milled flat. Using this technique, plates 1.27 cm (0.50 in.) thick of nickel 200 and zirconium copper were successfully butt welded.

Source: Gary H. Apple of
The Garrett Corp.
under contract to
Langley Research Center
(LAR-10802)

No further documentation is avilable.

Section 3. Coatings and Coating Techniques

REDUCING STICKING OF REACTING PACK MATERIAL IN A PACK COATING PROCESS

Pack-retort coating processes are used commercially for coating carbon-base materials and metal alloys. In retort operations, the removal of well-coated parts from the pack material is a major problem. A new technique solves the problem for the pyrolyzed plastics used in the aerospace industry and, with modification, may be able to do the same for commercial processes with carbon-base or metallic materials.

The unwanted adherance of the parts is eliminated by altering the composition of the pack material. The result has been an increase in the allowable service temperature for the parts and a higher number of usable parts from each processing batch.

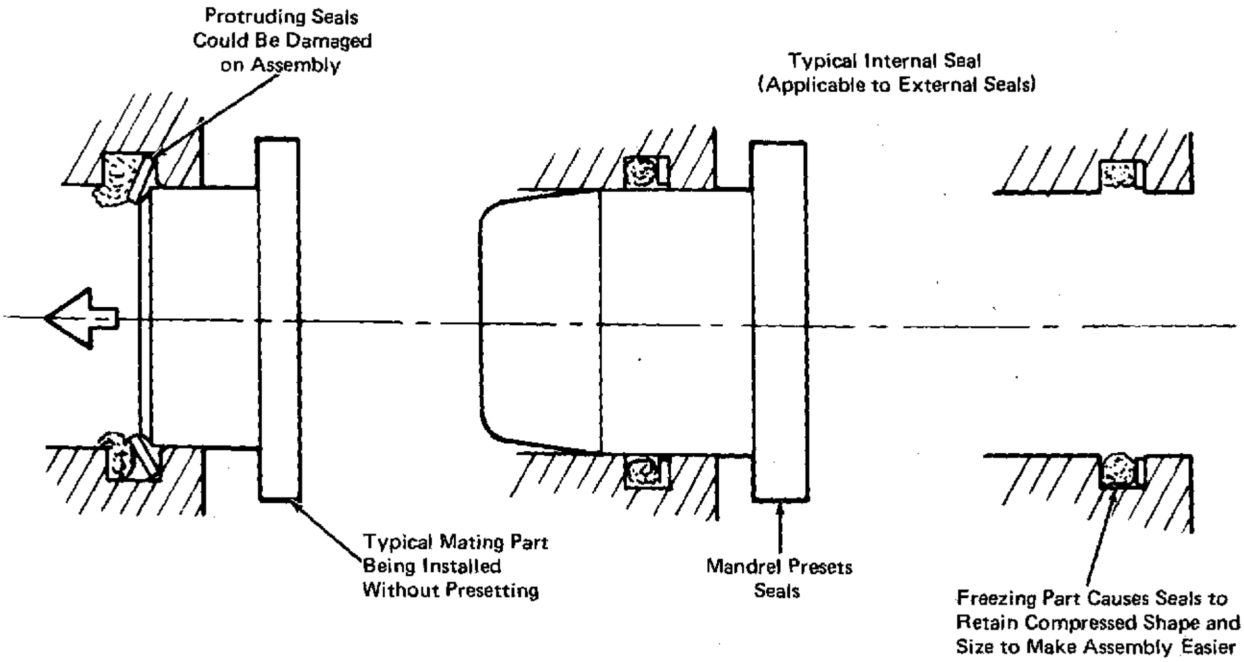
The pack material is modified by the addition of an oxidation-inhibitor system. The parts are coated with a slurry of the following (by weight-percent): 40% silicon metal powder, 40% silicon carbide, and 20% aluminum oxide powder in isopropanol. The pack material is a uniform blend of 30% silicon metal powder and 70% silicon carbide. A cover layer of carbon black is used to isolate the system.

The packed retort is placed overnight in an air-circulating oven at 420 K (300° F) to drive out moisture and any residual isopropanol. While the retort is still hot from the drying process, it is placed in a high-temperature diffusion furnace. Then the system is evacuated and backfilled with argon. After four hours, the specimens are removed and cleaned.

Source: D. C. Rogers of
LTV Aerospace Corp.
under contract to
Johnson Space Center
(MSC-14045)

Circle 7 on Reader Service Card.

HIGH-RELIABILITY, ELASTOMER-SEAL INSTALLATION



Elastomer-Seal Installation

Present O-ring installation methods frequently damage the seal during matchup with mating parts. Leaking seals are not identified until proof testing or cyclic operation takes place.

A novel procedure (see figure) provides a means of inspecting, in detail, the expanded or compressed seal assembly prior to matchup. A Teflon-covered mandrel is used to stress the O-ring and retainer. The assembly is then cooled to approximately −110° F (195 K) by immersion in a liquid acetone bath. After cooling, the mandrel is removed, leaving the frozen seal in its stressed position available for inspection. Assembly is facilitated because the seal offers no resistance to the entry of mating parts. When assembly is complete, the seal is warmed to ambient temperature in an insulated box containing a heat lamp.

This technique may be of interest to the fluid power and cryogenic chemical industries, as a way of increasing seal reliability in valves, pumps, and other equipment.

Source: D. E. Necker and C. L. Byrd of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17474)

No further documentation is available.

ADAPTER AND DISPOSABLE BAG FOR SPRAY GUNS

Whenever paint must be sprayed in an area too small for a conventional spray-paint container, this small paint container may be used. The container is a polyethelene bag, less than 13 in. (5 cm) high, that can be attached to a conventional spray gun with an inexpensive adapter. Because no venthole is needed, the system is dripless.

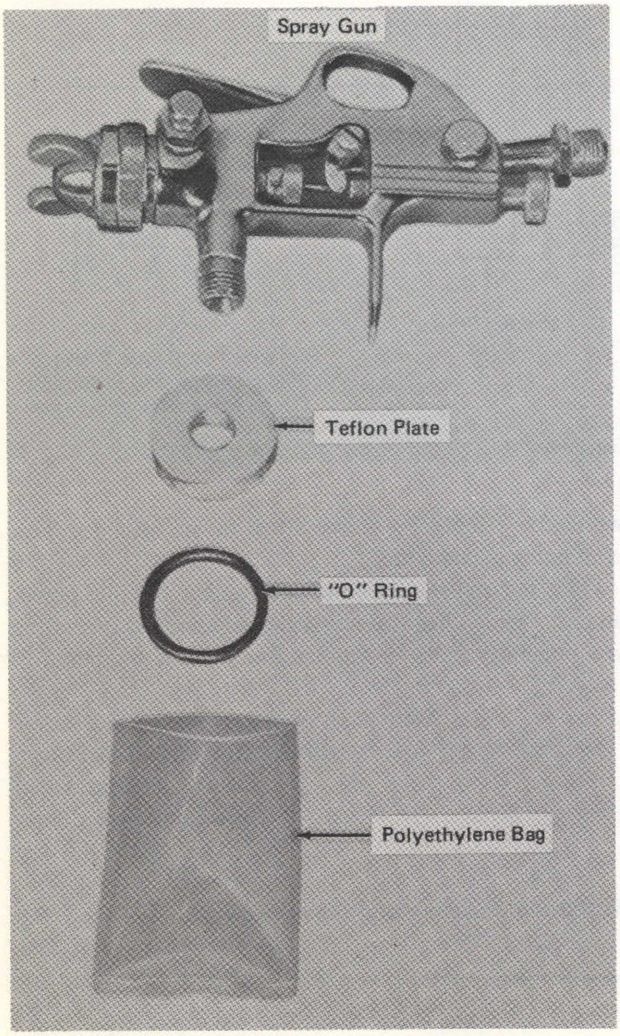


Figure 1. Adaptor Components for Spray Gun

The bag and adapter parts are shown in Figure 1, and Figure 2 shows the assembled spray gun. The adapter is made by machining 1/8 in. (0.32 cm) thick Teflon plate (metal or plastic may also be used) to a diameter of 1-3/8 in. (3.50 cm) with a 1/32-in. (0.079-cm) groove on the exterior circumference. A hole is drilled in the plate to fit the gun at the same place a paint cup normally would.

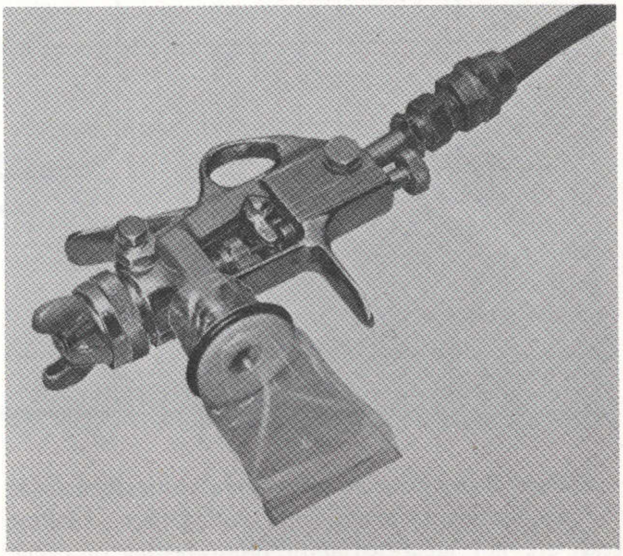


Figure 2. Assembled Spray Gun

The adapter plate is placed inside the top of the polyethelene bag and is held in place by an O-ring. Paint is added by removing the adapter plate from the gun, with the bag attached.

Source: K. W. Fee of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17177)

No further documentation is available.

A NEW POTTING, SEALING, AND CONFORMAL COATING SYSTEM

Two potting compounds, a seal coat, and a conformal coating have been developed to meet the stringent requirements of manned spaceflight. The entire system is nonflammable, has a low density, and is easy to repair. For these reasons, the formulations may be useful in other cases in which quality and safety are important.

One of the potting formulations is an entirely inorganic mixture, made of asbestos fiber, silica, glass microballoons to reduce density, and sodium silicate. These components are mixed with a silica aquasol and cast into a mold. The asbestos fiber lends added strength and the microballoons contribute to ease of repair.

The second potting compound is a primarily inorganic system having a nonflammable fluorinated elastomer as the binder. The formulation consists primarily of the fluorelastomer, asbestos, and glass microballoons. Methyl ethyl ketone and methyl isobutyl ketone are used as solvents.

Both potting compounds require a sealer coat. For this purpose, a mixture of fluorelastomer, magnesium oxide, and tabular alumina are used. Methyl ethyl ketone is the solvent for the sealer.

The conformal coating is a mixture of a brominated polyester, tabular alimina (a filler), and a small amount of cobalt napthenate (to aid in the cure). The coating is applied without a solvent to reduce porosity.

The system lends itself to most fabrication techniques; the potting compounds can be applied with a syringe or a caulking gun, and the sealer and coating can be brushed or dipped on. The compounds can be worked several hours after preparation and will cure at room temperature in less than a week. For repairs, the compounds can be removed mechanically without damaging wires or components.

The performance of the system meets most of the stringent requirements of the space program. The system has a wide temperature range, is an excellent insulator, undergoes negligible outgassing, and is moisture resistant and flexible.

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $1.45)

Reference: NASA-CR-108492 (N70-33745), Development of Inorganic Nonflammable Spacecraft Potting, Encapsulating, and Conformal Coating Compounds

Source: S. H. Foster and
K. H. Lothrop of
Emerson and Cuming Inc.
under contract to
Johnson Space Center
(MSC-13479)

APPLICATION OF A SOFT-ANODIZING PROCESS FOR OPTICAL INSTRUMENTS

A soft-anodizing process for optical instruments can produce surfaces comparable to those coated with black velvet paint in its ability to absorb light at large angles of incidence. Advantages of the process over paint are: (a) paint outgasses more than anodizing, (b) paint is more susceptible to flaking, chipping and scratching than anodizing and (c) paint has a tendency to seek sharp edges, while anodizing does not.

The primary application of the process is in the field of optical instruments used over long periods of time in a remote environment where maintenance cannot be conveniently performed. It is also intended for use where properties such as outgassing, flaking, and chipping cannot be tolerated, and where the special features of instruments such as knife edges must be maintained at the highest level of efficiency.

Source: J. F. Wade of
Martin Marietta Corp.
under contract to
Marshall Space Flight Center
(MFS-20365)

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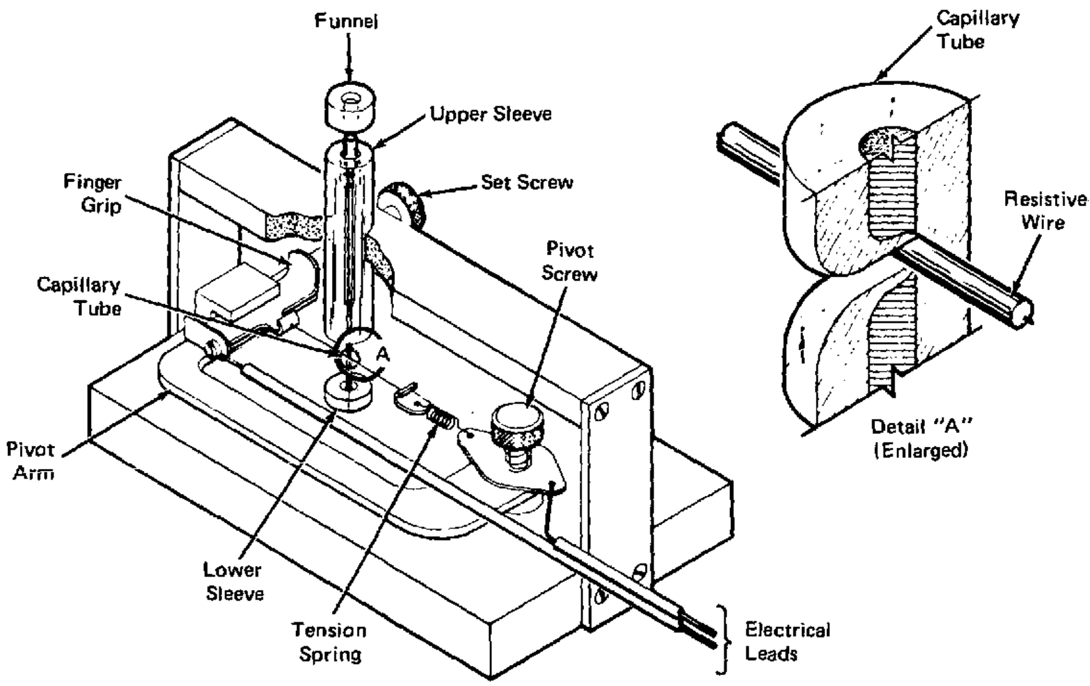
Section 4. Miscellaneous Fabrication Techniques

GLASS CAPILLARY TUBE CUTTER AND SEALER



Capillary Tube Cutter and Sealer

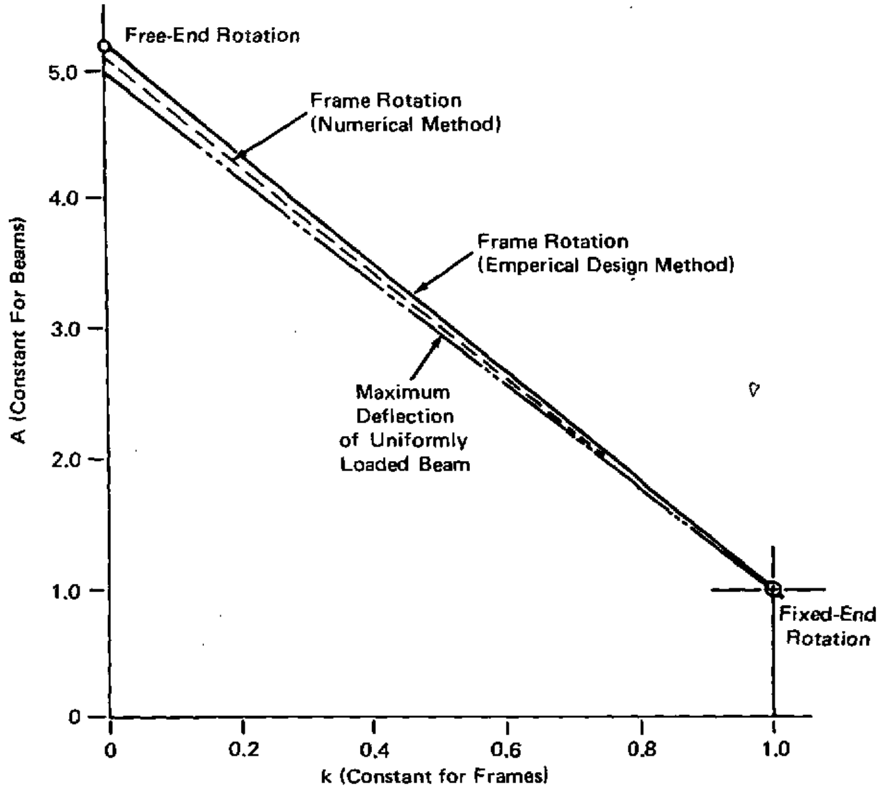
To encapsulate very fine powders in glass capillary tubes in controlled atmospheres, the tubes must be cut off and sealed to the desired lengths. This may be done conveniently with an inexpensive device that fits into a dry box and efficiently cuts and seals glass capillary tubes in selected lengths.

As shown in the figure, the device holds a capillary tube vertically and cuts off and seals the tube by severing it with an electrically heated wire that is moved horizontally. The capillary tube slips into, and is held in position by the upper and lower sleeves. The upper sleeve can be raised or lowered to accommodate varying lengths of capillary tubes, and is held in place vertically by a set screw. A funnel facilitates filling the tube. A resistive wire is electrically heated and held in a U-shaped pivot arm, which rotates about a pivot screw. The wire is made of a suitable alloy of platinum, rhodium or osmium. It is heated to a temperature of approximately 1366 K (2000° F) by a 24-volt dc power source through two electrical leads. The wire is kept in tension by a spring. A finger grip provides a means for swinging the pivot arm and wire, so that the wire cuts through and seals the capillary tube, as shown in the enlarged view. The cutoff bottom section of the tube is removed, the tube is lowered, and the upper end of the selected tube section is cut and sealed to produce the encapsulated sample.

Source: Margaret I. Alley and
Allan D. Smith
Lewis Research Center
(LEW-11899)

No further documentation is available.

REDUCTION OF STIFFNESS REQUIREMENTS FOR FLAT FRAMES



Comparison of Constants for Beam and Frame Equations

Large flat surfaces on structures such as aircraft are supported by frames. Standard references present the designer two criteria for selecting the proper frame strength: (1) the frames may have fixed ends, or (2) the ends of the frames may have complete freedom of rotation. In practice, the ends of the frames frequently must have a limited but definite ability to rotate.

As a result, designers usually must choose the criterion for free frame ends. This conservative choice is structurally safe, but can be a case of extreme overdesign.

A new design approach fills the gap in the available techniques for determining frame stiffness. It may be applied to symmetric and nonsymmetric frame ends, including all cases intermediate between fixed and free.

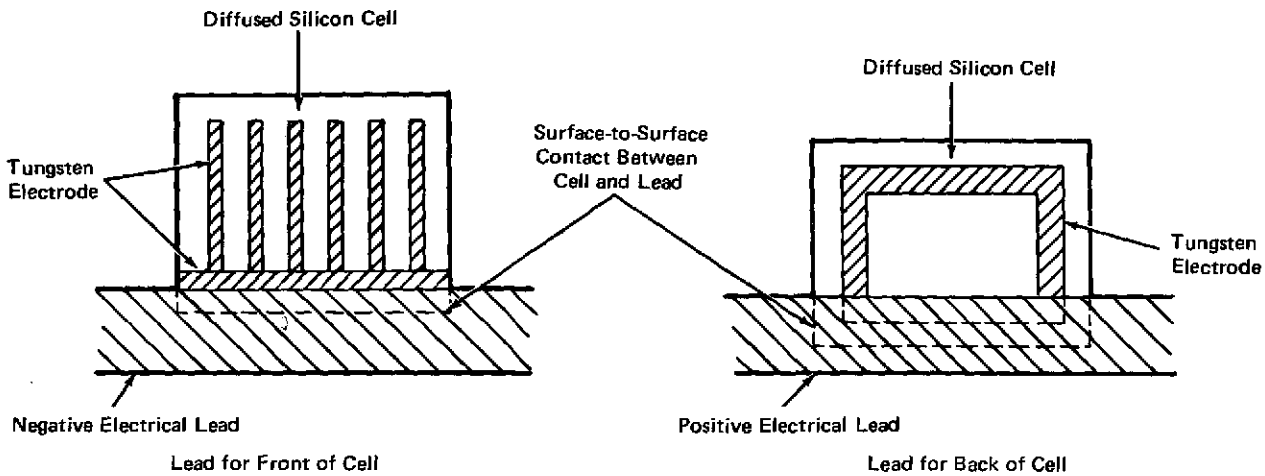
These design equations are based on the standard-reference expressions for frame stiffness for the two conditions: fixed and free rotation. The equations are derived from the solution of a fourth-order differential equation. Approximate solutions are available in the literature, however, only for the cases of fixed or free rotation.

An expression for intermediate cases has been derived and found to be dependent on a parameter k, a function of the end moment. This parameter can be determined by comparing frame stiffness to the elastic behavior of beams. These two expressions have nearly the same ratio of fixed-to-free end conditions and have matching intermediate points (see figure). From this relationship and from the expressions for beams and frames, it is found that k is related to the maximum deflection of a frame under a unit load and can be considered a spring constant. With this knowledge, intermediate values can be determined by interpolation with an empirical design equation, derived from the expressions for fixed beams and frames.

Source: H. Birnbaum and
J. W. Warren of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17789)

Circle 9 on Reader Service Card.

LOW-RESISTANCE CONTACTS FOR SOLAR CELLS



A Possible Solar Cell Configuration Using Tungsten Contact Electrodes

A new method improves the fabrication of low-resistance contacts for diffused-silicon cells. It has several advantages over the deposition of silver/titanium contacts and other existing methods. Silver/titanium contacts frequently separate from the cell at low temperatures, under a vacuum, or at high humidity. Tungsten contacts, deposited on the cells by any of several techniques, overcome many of the problems associated with the silver/titanium system. In addition, this new type of contact can be used with integrated-circuit chips as well.

Advantages of the tungsten-electrode contact include:

a. The contact is unaffected by humidity, vacuum, severe temperature variations, and other environmental factors.
b. The tungsten-electrode contacts have a very low contact resistance that enhances the electrical power output and efficiency of the cell.
c. The low contact resistance of the tungsten electrode allows the use of low-resistance solar cells in environments with intense electromagnetic radiation (the Van Allen belts, for instance).

Solar cells require two leads: Normally, a negative lead on the front of the cell and a positive lead on the back of the cell. The figure shows how the surface of the lead is joined with the surface of the cell.

The difference between this new technique and older methods is primarily due to the formation of a W-Si-O low-resistivity compound that provides an integral junction rather than a surface-adhesive layer. The tungsten may be deposited by standard methods such as evaporation, sputtering, or compression or diffusion bonding. The electrical connections may be made by joining the tungsten electrode to foils, wires, or expanded foils of tungsten or other materials. This may be done by inert-gas welding, arc welding, resistance welding, or similar processes.

The following procedure is recommended for fabrication of the tungsten-electrode contacts:

a. The diffused-silicon cell is masked to provide the desired contact-electrode configuration (see figure).
b. The exposed portion is polished, sandblasted, or chemically etched. (Care must be taken not to remove the diffused p-n junction of the cell.) The cell is then degreased and cleaned.
c. One of the standard processes is used to deposit the tungsten.

d. The cells with the contact electrodes are annealed to complete the formation of the W-Si-O compound. If the preceding deposition process required heating (e.g., sputtering or diffusion bonding), there is no need to heat at this point.

Source: Joseph Epstein
Goddard Space Flight Center
(GSC-10695)

No further documentation is available.

A TECHNIQUE FOR ADDING SOLDER BUMPS TO INTEGRATED CIRCUIT CHIPS

Fly-wire binding costs are a significant portion of the assembly costs of integrated and hybrid circuits. In addition, fly wires are a major source of failures.

Several methods have been considered for adding solderable metallurgy to off-the-shelf silicon integrated circuits (SIC's). Metal-stencil-mask vacuum deposition, for instance, has been found uneconomical unless the circuit geometry is expanded. However, solder bumps 3 to 4 mils (0.0075 to 0.01 cm) thick can be economically made with this new process.

The passivated wafers are etched to uncover the metal pads, and the solder is vacuum deposited on the pads through a photoresist pattern. For the vacuum deposition, the wafers are placed in a vacuum chamber containing molten solder. The vacuum is released suddenly. The abrupt increase in pressure forces the molten solder through the holes in the photoresist layer and into contact with the metal pads.

Source: J. F. Burgess,
R. F. Girard, C. A. Neugebauer,
and C. J. Watters of
General Electric Co.
under contract to
Johnson Space Center
(MSC-14402)

Circle 10 on Reader Service Card.

GRAPHS OF STRESS AND TENSION PROPERTIES OF BOLTS

A new set of graphs describes the allowable loads for structural bolts under combined tension and shear. The graphs have been developed to aid in the design of ground-support equipment at Kennedy Space Center. They are a more handy reference than tables, and thus allow design engineers to select the proper bolt quickly, without resorting to laborious calculations.

The allowable loads are calculated from standard stress equations. The graphs cover standard ASTM bolts of several grades and sizes. Therefore, the data are reliable and inclusive, yet are convenient and easy to use. They are particularly useful because the relative strengths of bolts are much more apparent from these graphs than from calculations or tables.

Source: James R. Douglas of
The Boeing Co.
under contract to
Kennedy Space Center
(KSC-10493)

Circle 11 on Reader Service Card.

Patent Information

The following innovations, described in this Compilation, have been patented or are being considered for patent action as indicated below:

Fabrication of Irregular Surface Shapes (Page 8) MFS-22205

Inquiries concerning rights for the commercial use of this invention should be addressed to:

Patent Counsel
Marshall Space Flight Center
Code CC01
Marshall Space Flight Center, Alabama 35812

Low-Resistance Contacts for Solar Cells (Page 20) GSC-10695

This invention has been patented by NASA (U.S. Patent No. 3,664,874). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Goddard Space Flight Center
Code 204
Greenbelt, Maryland 20771